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(54) Title: METHOD FOR GENERATING 3D COMPUTER GAMES, AND COMPUTER GAMES USING THE METHOD

(57) Abstract

There is provided a method for generating a composite, three-dimensional-like computer game, by interactive assembly and processing of two or more separate image sequences. A bank containing a plurality of main sequences of true-life origin is provided. These sequences being shot separately, or extracted from one source. Secondary sequences are shot separately or extracted from one source, whereas their contents are at least roughly related to the contents of the main sequence, and stored in another bank. The secondary sequences are selected as a function of the selected main sequences. The positioned relationship of the secondary sequence and the main sequence is selected, and each secondary sequence is processed. The player selects the main sequence which is displayed together with its related secondary sequence(s). The main and secondary sequences are processed on-line according to inputs provided by the player. Optionally, computer-generated images are displayed with the main or secondary images.

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METHOD FOR GENERATING 3D COMPUTER GAMES, AND COMPUTER GAMES USING THE METHOD

Field of the Invention

The present invention relates to the field of image processing. More particularly, the invention relates to a method for generating computer games, to computer games using the method, and to display means for playing the game.

Background of the Invention

Computer games are widespread nowadays. They typically employ a bank of computer-generated images and of sounds, which are either recorded or computer generated, and which are combined according to predetermined rules, to produce a sequence of actions related to actions taken by the player. Thus, interactive games employ the power of the computer to cause a specific occurrence, or a specific series of occurrences, to take place as a result of input provided by the player.

The technology employed in the art suffers from several severe drawbacks, the most important of which being: 1) that there is only a limited feeling of reality, no matter how high the quality of the image; and 2) more importantly, the cost of generating computer images is very high.

Even in some instances, where computer-generated images have been substituted by real shots, the feeling of reality is minimal, because no depth of the scene is obtained, and in this respect the situation is even worse than with computer generated images, where 3D-like images can be produced. Furthermore, only a small number of shots can be used, because of image processing limitations, which affects the feeling of continuity of the game. Above all, however, the existing computer games employing real-life shots are uninteresting, because they lack reality and 3D feeling, and because they are made of a narrow choice of repetitive sequences of events.

In a copending patent application (WO 95/33340), the description of which is incorporated herein by reference, several considerations pertaining in general to the generation of 3D-like sequences of images are detailed. These are further briefly discussed below, for ease of reference.

There are several known methods to perceive depth. Examples are stereoscopic perception of depth, psychological perception of depth using visual cues and the use of changing focus to perceive depth. A viewer viewing a scene in which the focal point changes will perceive that the scene has depth.

Stereoscopic depth perception requires that the viewer views a scene from two different locations at the same time. In real life, this means that he sees the same scene using both his left eye and right eye, each eye perceiving a somewhat different image. When two dimensional visual images are substituted for real life, it requires the use of two images taken from different right eye and left eye locations respectively.

On the other hand, a viewer can perceive depth by virtue of a number of psychological depth perception cues which are present in both real life and in two dimensional visual images. Common cues include effects where the change of coloring or softening of the shapes gives a feeling of distance to far objects, distribution of light and shade on an object, overlapping of contours as when a near object hides part of a more distant object, geometrical perspective for example in the case of the converging of the parallel rails of a railroad track as they extend in the distance, movement of an object in a visual image either towards or away from the viewer or audience, and movement for stimulating the Pulfrich effect

This is true of all the various devices in which two dimensional visual images are projected onto screens. Such devices include televisions, motion picture theaters, training simulators, multi-media systems and so on having applications in the areas of entertainment, work, education, exhibitions, training, etc.

A number of devices had been proposed to permit a viewer or an audience to view three dimensional visual images or at least the illusion of three dimensional visual images when viewing two dimensional visual images. These broadly fall into three groups: those which provide stereoscopic viewing, those which help create the psychological illusion of depth and those which display images on a three-dimensional display system, such as a surrounding screen.

Devices providing stereoscopic viewing generally require the projection of two pictures of the same view, taken simultaneously by more than one camera from slightly different angles, to emulate the binocular vision of normal eyes. Several examples are shown in U.S. Patent Nos. 4,420,230 to McElveen, 4,714,319 to Zeevi, and 5,225,861 to Marks. The use of a vibrating mirror or screen is shown in U.S. Patent Nos. 4,130,832 to Sher and 3,814,513 to Nims et al. Other systems require special spectacles to be worn by the viewer or other devices which direct the proper view to the proper eye. All these systems are cumbersome and costly to use. Also, they tend to cause an uneasy feeling in the observer often resulting in headaches that may become severe. Thus these systems have failed to become popular.

The second approach is shown in U.S. Patents 4,651,219 to Rickert, 3,582,961 to Shindo and 4,000,367 to Field wherein depth perception is

provided by isolating the image to be viewed. In this way, the stereoscopic cues of the space surrounding the image are suppressed so that the inherent psychological depth indicators in the picture can be sensed by the observer who perceives a two dimensional visual image as a three dimensional scene. Other devices which produce a similar result are described in U.S. Patent No. 3,820,873 to Redington et al., U.S. Patent No. 4,154,514 to Harvey which utilize a curved screen, and U.S. Patent No. 4,941,041 to Kenyon which utilizes the Pulfrich illusion.

Other devices for providing three dimensional viewing are also described in the following U.S. Patents:

U.S Patent No. 2,468,046 to de los Monteros discloses an apparatus for projecting and viewing images with a depth effect through the use of at least one mirror to reflect the image from a projector onto a screen such that a degree of displacement between the images produces the illusion of stereoscopy.

U.S. Patent 3,514,871 to Tucker discloses a wide angle visual display for a training simulator which eliminates distracting discontinuities found in many wide angle displays. It does so by providing three virtual image lenses between the viewing point and the two dimensional displays and by providing substantial duplication of the projected computer generated

image on the marginal portions of the displays. This creates binocular vision at the corners of the displays which gives the illusion of three dimensionality.

U.S. Patent 5,274,405 to Webster describes a device into which the head is placed wherein images are projected both to the area of visual attention and the area of peripheral vision of each eye. The images are focused on the screens to provide sharp stereoscopic viewing throughout the field of view.

Another technique which is also known in the art is to take pictures of an object, e.g., a room, from different points of view, and to generate therefrom sets of spatial parameters, or database for novel view synthesis. Such a method is described, e.g., in "S. Avidan and A. Shashua, Novel View Synthesis in Tensor Space, Hebrew University Technical Report, 1996" (also available from the World Wide Web at http://www.cs.huji.ac.il). This method permits to generate three-dimensional images of the object, and to generate new images extrapolating from the parameters so obtained. This method (called hereinafter "the parameters method", for the sake of brevity) is a suitable method also for generating games according to the present invention, as will be understood from the description to follow. It suffers, however, from the drawback that substantial computational power is required to carry it out. Nevertheless, as less expensive computing power is

made available to the public constantly, the aforesaid parameters method is a suitable candidate for the purposes of the invention.

Other methods for producing three-dimensional moving images are based on computer generated images. An example is U.S. Patent 5,184,956 to Langlais et al., where computer generated data is used to produce a three-dimensional display for the purposes of driving training. It is easy to appreciate by any one skilled in this field that it is not difficult to adapt computer generated imaging techniques to many types of display systems such as stereoscopic display, wide angle display, and also three-dimensional display. This is so because the entire information required of each part of the image is known to the computer's program - including all the three-dimensional structure of each object, its surface color, texture, and so on. This seeming advantage is also the major disadvantage of such systems: the preparation of a realistic image requires painful and elaborate design of each and every detail. Thus the display is either non-realistic or else extremely expensive and laborious.

The method for generating a composite, three-dimensional-like image sequence according to WO 95/33340, by the assembly of two or more separate image sequences, comprises the steps of:

(a) providing a main sequence of images;

(b) providing at least one secondary sequence of images the contents of which are at least roughly related to the contents of said main sequence;

(c) selecting the positioned relationship of each of said at least one secondary sequence of images and of said main sequence of images;

(d) processing each of said at least one secondary sequence of images so as to optimize its matching with said main sequence in the selected positioned relationship with it; and

(e) displaying said main sequence of images and said secondary sequences of images at the same time and in substantially the same positioned relationship as selected in step (c) above.

The term "three-dimensional-like" as used herein (also referred to herein as "three dimensional", for the sake of brevity), is meant to indicate a sequence of images which is displayed in more than one plane, and which thereby evokes the feeling of real action taking place around the spectator. This feeling, more fully described herein, gives the viewer the feeling of being "in the movie", and provides a sense of reality unattainable by regular movies which are displayed in one plane only, as hereinafter defined. The three-dimensional-like image sequence of the invention is "composite", inasmuch as, in order to obtain the said effect, more than one image is displayed, as

said, on different planes, the resulting whole image being composed of said different displayed images.

The term "plane", used herein in relation to the display mean on which a sequence of images is viewed, is to be understood to include display surfaces in general, even if they are curved to some extent, and the term "plane" should not be interpreted as meaning that concave or convex surfaces are excluded. Similarly, when reference is made to an image which lies substantially on one plane, this should be understood to include also an image which is displayed on a curved display, as explained above. Furthermore, it should be understood that it is possible to use curved displays essentially made of one piece, onto which a main sequence of images is displayed, along with one or more secondary sequences of images, each sequence of images occupying a different portion of the curved display or screen. As will be apparent to a skilled person, such a single, curved display is equivalent to a plurality of single displays, each used to display a single sequence of images. Furthermore, such a single curved display would necessarily be made of sections which substantially lie in different "planes", as defined above. when using curved displays.

The main sequence of images is preferably, but not limitatively, located in the central part of the composite displayed image. This is because the main image sequence is the standard by which the secondary image sequence is

processed, and it will further be, in many instances, of higher quality (in terms of resolution, number of frames, etc.) than the secondary image sequences. However, it is permissible to position the display displaying the main image sequence at some other position relative to the center of the picture, if technical or aesthetic requirements demand it.

Once the position of the main image sequence is selected, it is necessary to select the location of the secondary image sequences within the composite picture. There is no theoretical limitation to the location of the secondary image sequences, and some of them can be located, e.g., above or below the display which displays the main image sequence. (These alternative positions are not shown in the appended drawings, for the sake of brevity, since they are self evident from the description provided for the illustrative geometries). Furthermore, a secondary image sequence may border with a second secondary image sequence, and not with the main image sequence, whereby said second secondary image sequence borders, e.g., with the main image sequence. However, for most applications, when it is desired to simplify and reduce the cost of both the process of creating the three-dimensional image sequence, and of displaying it, it is preferred to position the secondary sequences beside the main sequence.

As stated, in order to provide a three-dimensional-like image, it is necessary that different image sequences be displayed on different planes. Typically,

the display on which the main sequence is viewed is positioned at an angle with the one or more displays on which the at least one secondary sequence is viewed. The term "positioned at an angle", however, should be interpreted here to indicate that at least a major portion of the secondary image sequences lies on planes (as hereinbefore defined) which intersect the plane on which the main image sequence is displayed, no matter what the actual interface between the display means of the secondary image sequences and of the main image sequence are. Thus, for instance, curved displays may be used, if desired, where the transition from the display of the main image sequence to that of the secondary image sequences is smoother than when using two fully planar displays, positioned at an angle with respect to one another.

As stated, the secondary image sequences are processed in order to provide a matching with the main image sequence. Therefore, according to one preferred embodiment of the invention one or more of the secondary sequences of images has been recorded at a time different from the time at which the main sequence of images has been recorded.

One or more of the secondary sequences of images may have been recorded at a location different from the location at which the main sequence of images has been recorded.

Furthermore, one or more of the secondary sequences of images may be computer generated. It is also possible to mix images of different origin. Thus, for instance, in one particular embodiment of the invention some of the images in a sequence of images are computer generated, and some are images acquired by movie or VCR equipment.

According to a preferred embodiment of WO 95/33340, the main sequence of images and the secondary sequences of images are recorded on different media. Typically, but non limitatively, the media on which the sequences of images are recorded is selected from among film, video and digital data.

In many cases, and particularly when different recording and/or displaying methods are used for the main image sequence and for the secondary image sequences, the number of images in a first sequence, for a given sequence display time, may not match the number of images in a second sequence to be displayed together with said first sequence, for the same display time. According to a preferred embodiment of WO 95/33340, therefore, the method further comprises matching the image sequences to be displayed together so as to reach essentially identical starting and ending times of display for all sequences.

As stated, the secondary image sequences are processed to optimize their matching to the main sequence of images. According to a preferred

embodiment of WO 95/33340, the processing of a secondary sequence of images comprises matching the field of view of said secondary sequence to that of the main sequence. According to another preferred embodiment of WO 95/33340, the processing of a secondary sequence of images to optimize its matching to the main sequence of images comprises matching the apparent motion of said secondary sequence to that of the main sequence. As will be apparent to a person skilled in the art, the term "apparent motion" embraces two different types of movements: the first, is the movement that the camera appears to make relative to the scene being recorded, as viewed by the observer. For instance, if the camera rotates 0.3° per frame in the main sequence, to concentrate on an object that was previously at the edge of its field of view, the images in the neighboring secondary sequences must likewise rotate, at the same angular rate.

The second type of apparent motion is that of an object within the image sequence. If, for instance, there is a road extending from the main sequence into a secondary sequence, and a car travels on that road, it cannot appear to change speed abruptly when it reaches the edge of the main sequence, but its movement must continue smoothly on the display of the secondary image sequence. However, in some cases less accuracy of transitions from main to secondary images may be sufficient. For example, for scenes which comprise many objects (more than 100), accuracy and smooth transition is required for the ensemble of all objects in general, but less accuracy may be

sufficient for every individual object of said ensemble appearing in the scene.

In yet another preferred embodiment of WO 95/33340 the processing of a secondary sequence of images to optimize its matching to the main sequence of images comprises matching the displayed action of said secondary sequence to that of the main sequence.

As will be apparent to a person skilled in the art, other parameters of the image can be processed to improve the matching of the image sequences. For instance, in a preferred embodiment of WO 95/33340 the processing of a secondary sequence of images to optimize its matching to the main sequence of images comprises matching the colors and shades of said secondary sequence to that of the main sequence.

One advantage of the invention described in WO 95/33340 is that it is not necessary to provide in all cases image sequences of high quality and resolution. According to one preferred embodiment, for instance, the resolution of the images in a secondary sequence of images may be lower than the resolution of images in the main sequence of images.

It has now been found, and this is an object of the invention, that it is possible to generate computer games which exploit the three-dimensional

like effect obtained by the method described above, and which lead to substantially improved visual quality and lower costs.

It is an object of the invention to provide a method for generating 3D-like computer games, which employ real shots.

It is another object of the invention to provide computer games which employ the method of the invention.

It is a further object of the invention to provide means for playing the computer games generated according to the invention.

Other objects and advantages of the invention will become apparent as the description proceeds.

SUMMARY OF THE INVENTION

The method for generating a composite, three-dimensional-like image sequence, by the interactive assembly and processing of two or more separate image sequences comprises the steps of:

(a) providing a bank containing a plurality of individually selectable main images or main sequences of images, said images being images of true-life origin and said images or sequences being shot separately, or extracted from one source;

(b) providing at least one bank of secondary images or sequences of images, said images or sequences being shot separately or extracted from one source, the contents of which are at least roughly related to the contents of said main sequence, said secondary sequences being selectable as a function of the selected main images or sequences of images;

(c) selecting the positioned relationship of each of said at least one secondary images or sequences of images and of said main images or sequences of images;

(d) pre-processing each of said at least one secondary image or secondary sequence of images so as to provide a desired processed image;

(e) providing selecting means to select a main image or a main sequence of images, as the result of an input provided by a player, wherein said selected main image or main sequence of images is displayed together with its related secondary image(s) or sequence(s) of images, at the same time and in substantially the same positioned relationship as selected in step (c) above;

(f) providing means for on-line processing said main image and said secondary image, as a function of an input provided by a player;

(g) optionally, playing a sound related to said main sequence of images and said secondary sequences of images, and/or playing or

generating additional outputs related to such sequences of images; and

(h) optionally, displaying at the same time non-real life, computer-generated images in superimposed positioned relationship with the main or secondary images.

The pre-processing referred to in (d) above may be effected to obtain many different results. For instance, pre-processing can be aimed at optimizing the matching of the image with said main image or main sequence of images in the selected positioned relationship with it, or to create a database of image parameters, or to change one or more of its characteristics, etc.

By "images of true-life origin" is meant to indicate images which have been recorded with a camera or the like recording means, and which are not drawings or computer-generated images, but which may have been processed, or combined with other images, or drawn on. The bank of images contains shots taken by the various cameras, which are organized in sequences, but which can also be utilized singularly. Thus, for instance, when it is desired to generate an image on a side screen, or as a result of a joystick movement, e.g., zooming in, it is possible to utilize an out-of-sequence shot, taken from the bank, whenever this is suitable to create the desired result. Various combinations of shots and sequences are of course

possible, as will be appreciated by the skilled person, and such options are therefore not reviewed herein in detail, for the sake of brevity. Thus, each image stored in the image bank has, associated with it, a set of parameters which define it, in terms which are related to the type of game being played, and which permit easily and quickly to locate it, when needed for a given purpose, within the image bank. The number and nature of the parameters used to characterize an image may vary from one game to another, and is solely dictated by the needs of the specific game. Thus, the selecting means used to select a given image of sequence of images, may comprise database managing software, used to locate and retrieve images efficiently.

By "extracted from one source" it is meant to indicate a procedure whereby a broad view movie, which has been shot with a wide lens, or which is a combination of two or more movies matched together using image processing and/or mosaic artwork techniques, is used to generate therefrom separate images or sequences of images. In some cases matching may be implemented without image processing.

According to a preferred embodiment of the invention, the main image and the secondary images are processed, as a function of an input provided by a player, so as to zoom in or out of the original image stored in the image bank. According to another preferred embodiment of the invention, the main image and the secondary images are processed, as a function of an

input provided by a player, so as to simulate the turning of an observer's head.

Other types of image processing are of course also possible and desirable. For instance, in one preferred embodiment of the invention the main image and the secondary image are processed, as a function of an input provided by a player, so as to change the speed of movement of the observer.

Other types of suitable processing includes the generation of images by the parameters method described above. Thus, according to this method, whenever relevant parameters such as location, view angle, zoom, etc. (referred herein sometime also as "the observer") change, a new image is generated using the parameters previously made available by the analysis of the real life images taken.

The additional outputs related to such sequences of images, which can be played or generated, include any kind of stimuli that it is desired to associate with the game, for instance, shaking of a seat, smell, smoke, etc. According to a preferred embodiment of the invention, the sound played is not necessarily associated with the main image being displayed, but may be associated with the value of the input provided by the player. Thus, the same image or set of images may be accompanied by different sounds if it has been displayed as a result of different inputs from the player. Thus, as

will be apparent to a person skilled in the art, a single image may be used to generate different sequences, and different sequences may be used to generate different scenes, depending on the development of the game.

The mixing of computer-generated and of real-life images can be extensively exploited, because the human mind tends to allow them to blend without finding disturbance in them. Thus, in some instances it may be more efficient and quick, if the input from the player required too heavy an image processing of the image available from the image bank, to generate a suitable image, or a part thereof, through the computer, rather than utilizing a real-life image. This, for instance, is convenient when a game includes gun shots, explosions, or other occurrences requiring special effects. Typically, however, the main image and the secondary image are processed, as a function of an input provided by a player, so as to create an image corresponding to that seen by an observer from a different point of view, or so as to zoom in or out of the original image stored in the image bank, similarly, to the eyes of the player moving closer of farther away from the scene.

The invention is also directed to a bank of selectable, composite, three-dimensional-like image sequences, which are generated by the method of the invention. Thus, in one aspect, the invention is directed to a bank of selectable secondary sequences of images, suitable to be used as a component of a computer game, comprising a main image or a main

sequence of images and at least one secondary image or sequence of images selectable together with said main image or sequence of images, said secondary image or sequence of images having a content that at least roughly matches the contents of the main image of said composite, three-dimensional-like sequence of images, and said secondary image or sequence of images further having been optimized for display together with said main sequence of images.

Without wishing to limit the invention in any way, it should be mentioned that in many cases it is preferred to provide images bigger than the screen by 25% to 100%, to allow flexibility in the image processing. In such a case, the image displayed is only a fraction of the total image, so that portions of the image which are not displayed for one desired viewing angle will be displayed when the input of the player corresponds to another angle.

The invention also encompasses an interactive computer game comprising:

(a) a bank containing a plurality of individually selectable main images or main sequences of images, said images being images of true-life origin;

(b) at least one bank of secondary images or sequences of images, the contents of which are at least roughly related to the contents of said main sequence, said secondary sequences being selectable as a function of the selected main images or sequences of images,

and each of said at least one secondary image or secondary sequence of images having been optionally pre-processed so as to optimize its matching with said main image or main sequence of images in the selected positioned relationship with it, or to obtain other results, as discussed above;

(c) means for selecting the positioned relationship of each of said at least one secondary images or sequences of images and of said main images or sequences of images;

(d) interaction and processing means to select a main image or a main sequence of images, as the result of an input provided by a player, wherein said selected main image or main sequence of images is displayed together with its related secondary image(s) or sequence(s) of images, at the same time and in substantially the same positioned relationship as selected in step (c) above;

(e) display means to display said main image or sequence of images, together with said at least one secondary image or sequence of secondary images, so as to provide a 3D-like feeling to the player;

(f) means for on-line processing said main image and said secondary image, as a function of an input provided by a player;

(g) means for playing a sound related to said main sequence of images and said secondary sequences of images; and

(h) optional means for displaying at the same time non-real life, computer-generated images in superimposed positioned relationship with the main or secondary images.

According to a preferred embodiment of the invention, the interactive computer game comprises means for controlling the speed of display of the frames on the display means. According to another preferred embodiment of the invention, the means for processing the main image and the secondary image, as a function of an input provided by a player, comprise image processing means suitable to generate from the image available from the image bank an image corresponding to that seen by an observer from a different point of view.

The computer game of the invention preferably, but non-limitatively, further comprises means for processing the main image and the secondary image, as a function of an input provided by a player, so as to simulate the turning of an observer's head. Further suitable means for processing the main image and the secondary image, as a function of an input provided by a player, comprise image processing means suitable to zoom in or out of the original image stored in the image bank.

The invention is further directed to visual display systems for playing three-dimensional-like computer games, comprising display means for displaying

a main image or main sequence of images, and at least one additional display means for displaying at least one secondary image or secondary sequence of images, said display means for displaying a main image or sequence of images, and said at least one additional display means for displaying at least one secondary image or sequence of images being positioned in substantially the same positioned relationship selected for the generation of the composite three-dimensional-like image.

Brief Description of the Drawings

The above and other characteristics and advantages of the invention will be more readily apparent through the following detailed description of preferred embodiments thereof, with reference to the appended drawings, wherein:

Fig. 1 schematically illustrates the overlap between three movies to be displayed simultaneously;

Fig. 2 (2A and 2B) illustrates the operation of a game, according to two different preferred embodiments of the invention;

Fig. 3 illustrates the result of a joystick movement simulating the turning of an observer's head; and

Fig. 4 schematically illustrates the operation involved in image processing with head turning, in the case where a larger image than displayed is available.

Detailed Description of Preferred Embodiments

In order to display an interactive 3d movie, three movies need to be prepared as shown in Fig. 1. This means that three films have been taken so that the three fields of view overlap to a certain extent, for example 25% of the field is overlapped in each side. Also, the captured images are vertically larger than required, typically in the same amount, say 25% on each side. It is very important that the three focal points of the cameras coincide, as otherwise the effect of tilting the three cameras together will look unnatural and the desired psychophysical effect will not be achieved. All this can be done either by using a gig of three rigidly mounted, fixed, calibrated cameras, or else, by using the preferred technique of filming the three sequences separately and then, using appropriate processing means and software, processing them to be fit for display on a 3D-like screen. The output of this stage is three image sequences, given on a digital video cassette, or, preferably, on a random access data device such as a computer hard disk.

According to a preferred embodiment of the present invention, the three separate movies of Fig. 1 above are merged into one "large" (broad view)

movie, using mosaic techniques. Thus, the resulting large movie is equivalent to a movie taken by using the same camera. Similarly, the large movie may be stored on a digital video cassette, or, preferably, on a random access data device such as a computer hard disk, or on any other suitable media.

Once this is ready, an interactive 3d movie can be presented in the following way. Reference is now made to Figure 2A. In the preferred embodiment shown in this figure, we have three image sequences residing in three computer disks, 211, 212, 213. The main computer 230 pulls sequentially the three sequences, and prepares them to be displayed on the three corresponding display means 241, 242, 243, which can be video screens, video projectors, LCD screens, or any other display means. It is important the display means will reproduce the geometry of the three cameras, as far as the geometry of the viewing eyes in relation to the displays will be similar (in the geometrical sense) to the geometry of the three (real or virtual) cameras. It should be kept in mind that the original image sequences have been taken with a field of view which is larger than that required to be properly displayed on a 3d-like display means. A computer interaction means 220 is provided, such as a mouse or a joystick, to allow interaction of the user with the system.

Fig. 2B illustrates the operation of a game according to a preferred embodiment of the present invention, using one large movie. The large movie is stored in a computer disk 280. The main computer 270 extracts the large movie sequence information and generates three sub-sequences, which size and relative location are a function of the desired position, which may be the center or any other position selected by the player. The main computer manipulates the side movie sequence(s) to represent the correct angles of the camera. Similar computer interaction means 260 is provided, such as a mouse or a joystick, to allow interaction of the user with the system.

This control mechanism provides parameters that effect the way that the images are displayed on the screen. In this particular embodiment the parameters are horizontal and vertical tilt (viewing angle), camera zoom, and motion speed. It is clear to anyone skilled in the art that many other parameters and parameter combinations can also be controlled or coupled to input devices, such as sound volume, chair wobble, mechanical effects, smell, digital video effects such as fog and many more. The following is a detailed description of how the image is prepared to be displayed, using the controls given by the interaction means, in this case horizontal tilt theta, vertical tilt phi (given in radians), zoom z (given as percentage of default image which is, say 70% of full image), and motion speed t (given as percentage of standard speed - 25 or 30 frames per second). First the

speed is controlled by standard video techniques, such as dropping frames and/or generating virtual frames to be displayed with or without original frames. For instance, virtual frames are generated in case when speed reduction is required, e.g., creating an intermediate frame interpolating between two existing frames (e.g., frame No. 1.5, interpolating midway between frames No. 1 and No.2). Zoom is controlled by clipping from the original image a larger or smaller sub-image and enlarging it to the required image size. In addition, zoom may induce compensations like, for instance, translation on secondary sequences. Rotation is done by the standard application of projective transformations, where a horizontal rotation of an image by theta is computed by the transformation:

$$x` = (x \cos(\text{theta}) - \sin(\text{theta})) / (x \sin(\text{theta}) + \cos(\text{theta}))$$

$$y` = y / (x \sin(\text{theta}) + \cos(\text{theta}))$$

while vertical rotation by phi is given by the transformation:

$$x` = x / (y \sin(\text{phi}) + \cos(\text{phi}))$$

$$y` = (y \cos(\text{phi}) - \sin(\text{phi})) / (y \sin(\text{phi}) + \cos(\text{phi}))$$

All in all, the final transformation involving zoom, vertical, and horizontal rotation is obtained by multiplying together the separate transformations, and then applying the result to the image. This can be done either by a

standard computer utilizing a fast CPU module such as a "Pentium Pro" which is sold by Intel Corporation, or by a computer assisted by specialized graphics hardware accelerators (video texture mapping module), such as an O2 workstation marketed by Silicon Graphics Limited, California, U.S.A..

Looking now at Fig. 3, four sequences of images are given (Fig. 3A through Fig. 3D), illustrating consecutive stages in the on-line image processing carried out during the game, as the result of an input by the player, corresponding to the turning of the head of the player to the left. Three images are shown, which, for illustration purposes are shown on a plane, but which should be understood to be positioned at an angle, e.g., as schematically shown in Fig. 1. The images are numbered 1-3, from right to left.

Each of the images 1, 2 and 3 , recovered from the data bank, contain more information than displayed. However, each image is masked so that only a portion thereof is shown. Thus, for instance, image (1) of Fig. 3A is taken with a broader field of view, which includes the details not seen in Fig. 3A, but which are seen in image (1) if Fig. 3D. Similarly, the details seen in the right hand side of image (1) of Fig. 3D are contained in the image (1) of Fig. 3A, but they are masked and therefore not seen. In this way, it is possible to provide an effect of change and movement, while

moving with the mask within the same image, without making any further processing of the image, except the masking. Before being cut or masked, the images are rotated according to the aforementioned (or alternative) formulae, to provide the effect of turning.

This procedure is further schematically illustrated in Fig. 4. The whole image available from the date bank is seen, together with the mask (the inner square) which shows the part of the image which is being displayed. In Fig. 4(a) the leftmost part of the building is displayed, and the portions of the building found outside the mask are not seen on the display means. A the head of the observer moves to the left (as a result of an input given, e.g., by a keyboard, a joystick, or other means) the mask also rotates to the left, showing portions of the building formerly not displayed, and hiding the earlier displayed leftmost parts of the building.

Turning again to Fig. 3, it should be remembered that while the movement of the head is effected, the game continues and the frames continue to be displayed, at the required speed. This is seen, for instance, by looking at image (3). In Fig. 3A the moving car is not only much more to the right than in Fig. 3D, but is also not as close to the observer. While the observer's head moved, the car has continued to advance.

Of course, this example and the above description has been provided only for the purpose of illustration, and are not intended to limit the invention in any way. As will be appreciated by the skilled person, the invention can be carried out in a great variety of ways, employing many different image processing techniques and apparatus, and using different images and images obtained and generated in different ways, all without exceeding the scope of the invention.

Claims

1. A method for generating a composite, three-dimensional-like image sequence, by the interactive assembly and processing of two or more separate image sequences, comprising the steps of:

(a) providing a bank containing a plurality of individually selectable main images or main sequences of images, said images being images of true-life origin, and said images or sequences being shot separately, or extracted from one source;

(b) providing at least one bank of secondary images or sequences of images, said images or sequences being shot separately or extracted from one source, the contents of which are at least roughly related to the contents of said main sequence, said secondary sequences being selectable as a function of the selected main images or sequences of images;

(c) selecting the positioned relationship of each of said at least one secondary images or sequences of images and of said main images or sequences of images;

(d) pre-processing each of said at least one secondary image or secondary sequence of images so as to produce a desired processed image;

(e) providing selecting means to select a main image or a main sequence of images, as the result of an input provided by a player,

wherein said selected main image or main sequence of images is displayed together with its related secondary image(s) or sequence(s) of images, at the same time and in substantially the same positioned relationship as selected in step (c) above;

(f) providing means for on-line processing said main image and said secondary image, as a function of an input provided by a player;

(g) optionally, playing a sound related to said main sequence of images and said secondary sequences of images, and/or playing or generating additional outputs related to such sequences of images; and

(h) optionally, displaying at the same time non-real life, computer-generated images in superimposed positioned relationship with the main or secondary images.

2. A method according to claim 1, wherein the main image and the secondary image are processed, as a function of an input provided by a player, so as to create an image corresponding to that seen by an observer from a different point of view.

3. A method according to claim 1, wherein the main image and the secondary image are processed, as a function of an input provided by a player, so as to zoom in or out of the original image stored in the image bank.

4. A method according to claim 1, wherein the main image and the secondary image are processed, as a function of an input provided by a player, so as to simulate the turning of an observer's head.

5. A method according to claim 1, wherein the main image and the secondary image are processed, as a function of an input provided by a player, so as to change the speed of movement of the observer.

6. A method according to claim 1, wherein the sound played is not associated with the main image being displayed, but is associated with the value of the input provided by the player.

7. A method according to claim 4, wherein the image displayed is only a fraction of the total image, so that portions of the image which are not displayed at one time are displayed when the input of the player corresponds to a turning of the observer's head.

8. A method according to claim 7, wherein the size of the image is 25% to 100% larger than the displayed image.

9. A bank of selectable, composite, three-dimensional-like image sequences, whenever generated by the method of claim 1.

10. A bank of selectable secondary sequences of images, suitable to be used as a component of a computer game, comprising a main image or a main sequence of images and at least one secondary image or sequence of images selectable together with said main image or sequence of images, said secondary image or sequence of images having a content that at least roughly matches the contents of the main image of said composite, three-dimensional-like sequence of images, and said secondary image or sequence of images further having been optimized for display together with said main sequence of images.

11. An interactive computer game comprising:

(a) a bank containing a plurality of individually selectable main images or main sequences of images, and said images or sequences being shot separately, or extracted from one source, said images being images of true-life origin;

(b) at least one bank of secondary images or sequences of images, the contents of which are at least roughly related to the contents of said main sequence, and said images or sequences being shot separately, or extracted from one source, said secondary sequences being selectable as a function of the selected main images or sequences of images, and each of said at least one

secondary image or secondary sequence of images having optionally been pre-processed;

(c) means for selecting the positioned relationship of each of said at least one secondary images or sequences of images and of said main images or sequences of images;

(d) interaction and processing means to select a main image or a main sequence of images, as the result of an input provided by a player, wherein said selected main image or main sequence of images is displayed together with its related secondary image(s) or sequence(s) of images, at the same time and in substantially the same positioned relationship as selected in step (c) above;

(e) display means to display said main image or sequence of images, together with said at least one secondary image or sequence of secondary images, so as to provide a 3D-like feeling to the player;

(f) means for processing said main image and said secondary image, as a function of an input provided by a player;

(g) means for playing a sound related to said main sequence of images and said secondary sequences of images; and

(h) optional means for displaying at the same time non-real life, computer-generated images in superimposed positioned relationship with the main or secondary images.

12. An interactive computer game according to claim 11, comprising means for controlling the speed of display of the frames on the display means.

13. A computer game as claimed in claim 11, wherein the means for processing the main image and the secondary image, as a function of an input provided by a player, comprise image processing means suitable to generate from the image available from the image bank an image corresponding to that seen by an observer from a different point of view.

14. A computer game according to claim 11, comprising means for processing the main image and the secondary image, as a function of an input provided by a player, so as to simulate the turning of an observer's head.

15. A computer game as claimed in claim 11, wherein the means for processing the main image and the secondary image, as a function of an input provided by a player, comprise image processing means suitable to zoom in or out of the original image stored in the image bank.

16. A visual display system for playing three-dimensional-like computer games, comprising display means for displaying a main image or main sequence of images, and at least one additional display means for displaying at least one secondary image or secondary sequence of

images, said display means for displaying a main image or sequence of images, and said at least one additional display means for displaying at least one secondary image or sequence of images being positioned in substantially the same positioned relationship selected for the generation of the composite three-dimensional-like image.

17. A method for generating a composite, three-dimensional-like image sequence, by the interactive assembly and processing of two or more separate image sequences, essentially as described and illustrated.

18. An interactive computer game, essentially as described and illustrated.

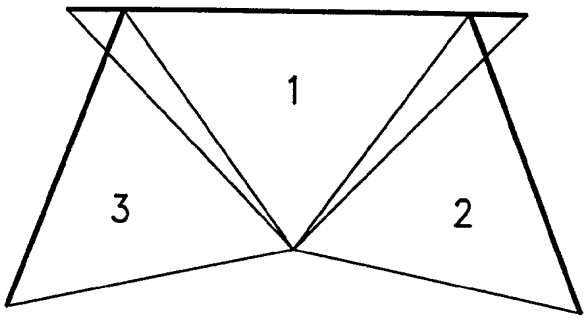

Fig. 1

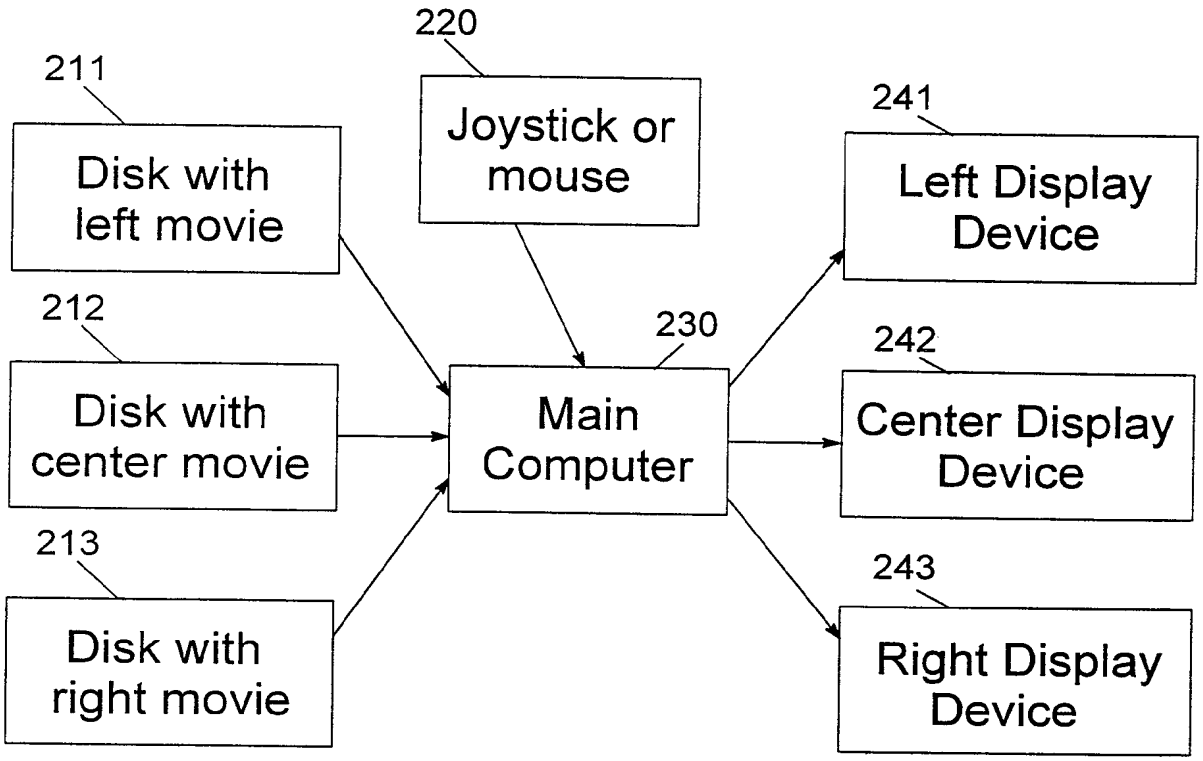
211
Disk with left movie
212
Disk with center movie
213
Disk with right movie
220
Joystick or mouse
230
Main Computer
241
Left Display Device
242
Center Display Device
243
Right Display Device

Fig. 2A

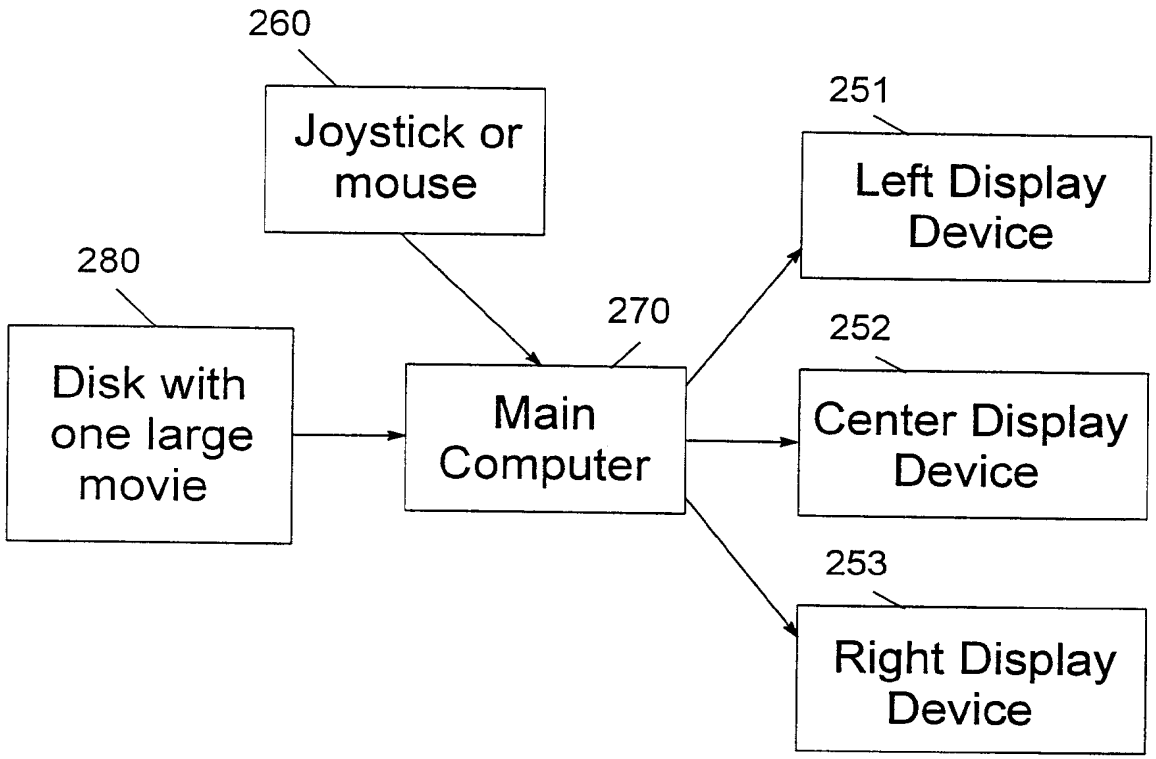
260
Joystick or mouse
251
Left Display Device
280
270
252
Disk with one large movie
Main Computer
Center Display Device
253
Right Display Device

Fig. 2B

Fig. 3A(1)

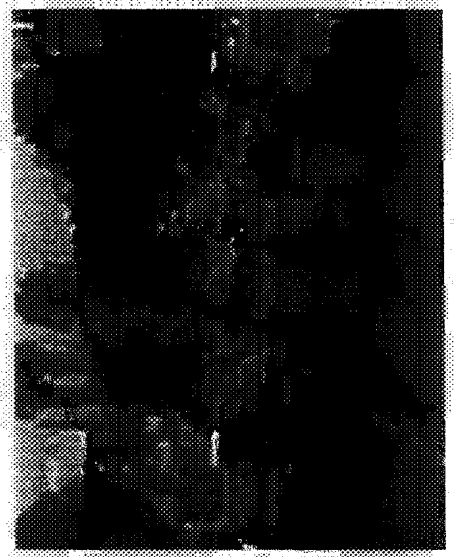

Fig. 3A(2)

Fig. 3A(3)

Fig. 3B(1)

Fig. 3B(2)

Fig. 3B(3)

Fig. 3C(1)

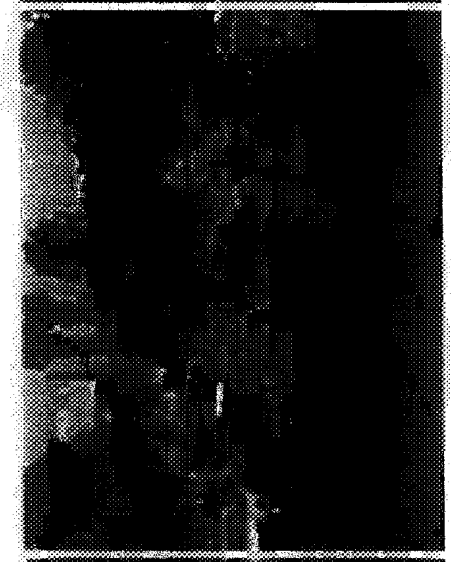

Fig. 3C(2)

Fig. 3C(3)

Fig. 3D(1)

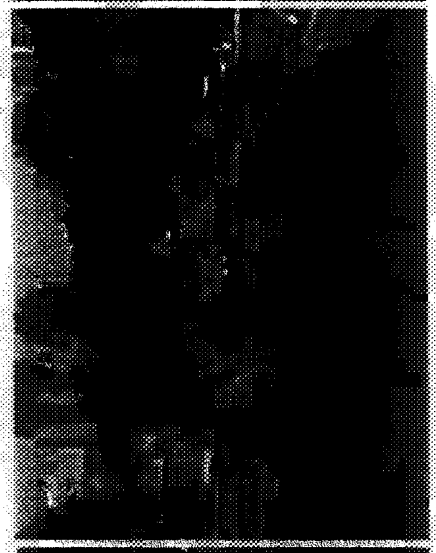

Fig. 3D(2)

Fig. 3D(3)

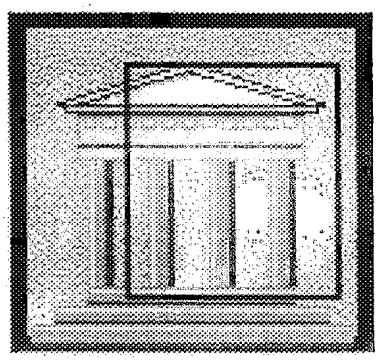

Fig. 4 A

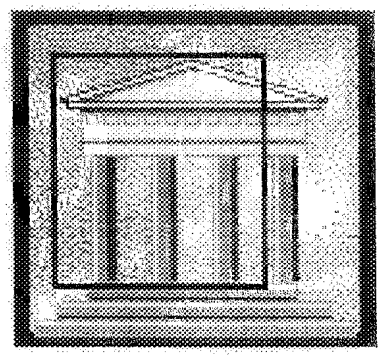

Fig. 4 B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL98/00137

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :A63F 9/22
US CL :463/31, 32, 36
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 463/6, 30-34, 36

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A, P	US 5,695,401 A (Lowe et al) 09 December 1997, see entire document.	1-18
A	US 5,616,079 A (Iwase et al) 01 April 1997, see entire document.	1-18
A	US 5,595,389 A (Parulski et al) 21 January 1997, see entire document.	1-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 17 AUGUST 1998	Date of mailing of the international search report 15 September 1998 (15.09.98)
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer For JAMES SCHAAF Telephone No. (703) 308-1148

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